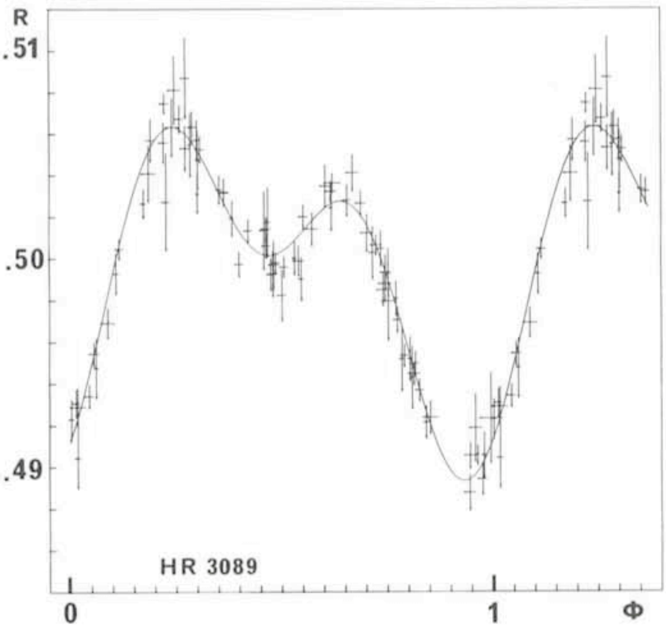

Fig. 2. — *The He I λ 4026 variability of the He-strong star HR 3089. The total range of the index, ΔR = 0.017 corresponds to an equivalent-width change of 225 mÅ. The average mean error is ΔR = 0.00094 or 14 mÅ. A five-term trigonometric function is fitted to the data which are folded modulo 1.33016 day.*

among these is the He-strong star HR 3089 for which a period of 1.33 day was found. A total of 82 observations of this star were collected during January, February, October and December 1976, with the Danish 50 cm at La Silla, the ESO 1 m and the CARSO 1 m telescope at Las Campanas. They are shown phase-resolved in Fig. 2 together with a five-term trigonometric function which fits the observations nearly as well as predicted by photon statistics.

At the end of my second visit to La Silla, Dr. Hardorp from Stony Brook, USA, encouraged me to make some measurements of the fast-rotating Ap star, CU Vir. Since the pro-

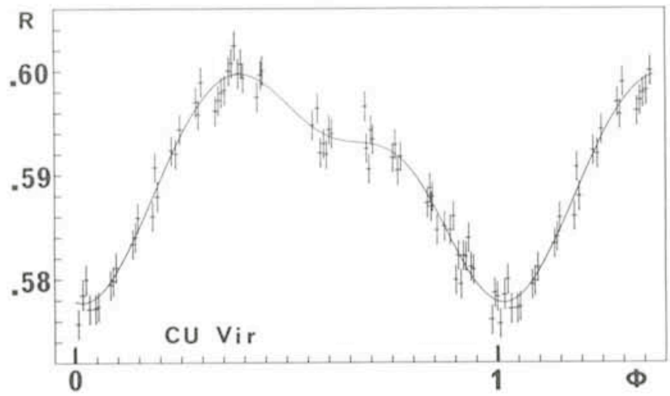

Fig. 3. — *The He I λ 4026 variability of the Ap star CU Vir. Since the observations were taken under nearly equal conditions, the individual mean errors have been replaced by the average mean error, ΔR = 0.00137. The curve is a seven-term trigonometric polynomium with a period of 0.52067688 day. Note the much smaller He line strength in this star as compared to HR 3089.*

gramme for the next observing run was already fixed, only a few hours could be spent on this star but the results nevertheless show a gain compared to conventional equivalent-width determinations. Each of the observations is the result of only 100 seconds integration time on the line band and 100 seconds on the continuum bands. Among other things, the phase-resolved data in Fig. 3 show that the index curve is asymmetric and possibly even has a secondary minimum.

At present, a graduate student, Mr. B. Prinds, is analysing the results for several of the He-weak and He-strong stars in order to find the surface distributions of Helium equivalent width. He "moves around" with imaginary circular spots of enriched He content and tries to make the computed index curve fit the observations when the star rotates. The number of free parameters, however, is so large, that a lot of very different but reasonable solutions seem to exist. This situation can only be changed when high-quality line profiles become available.

Optical Radiation Found in the Radio Lobes of Double Radio Galaxies

Philippe Crane and William C. Saslaw

Pushing the largest telescopes to their faintest limits is certainly not easy, but often extremely rewarding. The discovery of optical objects associated with powerful double radio sources (for which only the central galaxy was known before) will undoubtedly have a great impact on the study of the physics of radio galaxies. Two of the codiscoverers, Dr. Philippe C. Crane of the ESO Scientific Group in Geneva (formerly Princeton University) and Dr. William C. Saslaw, Institute of Astronomy, Cambridge, U.K., and University of Virginia, Charlottesville, USA, here review the new, fascinating discoveries—for the first time outside the professional journals.

When radio galaxies were first discovered in the 1950s, their most surprising property was that the radio and optical emission often came from different places. The most dramatic examples have a giant elliptical galaxy in the centre and two giant lobes of radio radiation on either side. A hundred kiloparsecs (1 pc = 3.26 light-years) is a typical distance between the galaxy and a radio lobe, although some sources spread over several megaparsecs. The radio lobes radiate about 10^{40}–10^{45} erg s^{-1}, and often surpass the optical radiation of the central galaxy in intensity. For comparison, the Sun radiates 3.8 x 10^{33} erg s^{-1}.

At first these radio sources were thought to be colliding galaxies. Now many more sources are known than can be produced by random collisions. Most astronomers believe that the central galaxy has emitted vast clouds of relativistic particles, or continuous beams of particles, or compact massive objects which generate the relativistic electrons in the radio lobes. To help constraining these theories, we

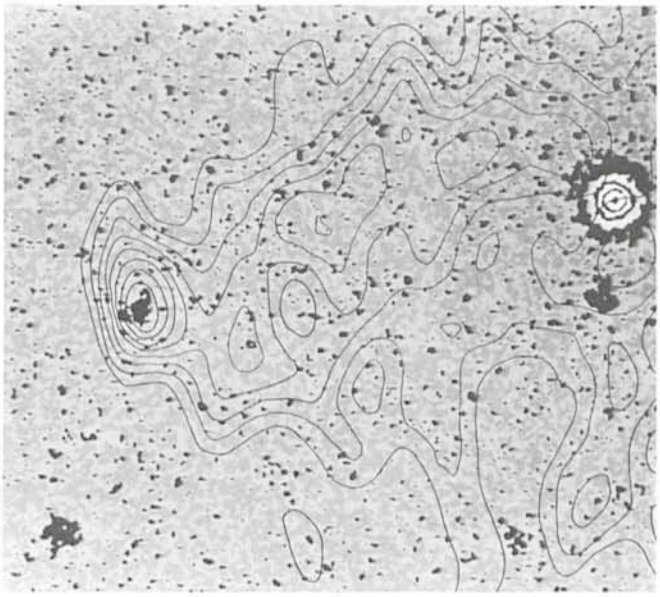

Fig. 1. — *This is a digitally-summed picture made from four 4-metre plates of the eastern radio lobe of the galaxy associated with the radio source 3C285. The radio contours from the Cambridge radio map have been overlaid. The bright object on the right has $V = 20.6$. The faint object centred on the radio hot spot has $B = 23.6$. The picture is 45" across. Both objects are discussed in the text.*

have been looking, in collaboration with J.A. Tyson of Bell Laboratories, for optical radiation in these radio lobes.

If there is optical radiation in radio lobes, it may have several causes. It could come from *free-free emission* or from *line emission* by thermal gas. However, we find that these causes would require an electron density $N_e \gtrsim 10^{-3} cm^{-3}$ which would depolarize the radio emission through Faraday rotation. Since most radio lobes are significantly polarized, this is an unlikely possibility. A second cause of optical radiation could be the same *synchrotron mechanism* that produces the radio emission. This would have the feature that it would be more highly polarized than the radio radiation, since there is much less Faraday depolarization at the high optical frequencies. A third cause of optical radiation could be *inverse compton scattering* of the universal 3°K microwave background by the relativistic electrons in the radio lobe. This optical emission would not be polarized, so it could be distinguished from optical synchrotron. There are other possible causes for optical emission in radio lobes, but these are the major ones.

With this in mind, we started a sensitive systematic search for such optical emission. Since we needed high-resolution radio maps, southern galaxies were excluded as there is no high-resolution radio interferometer in the southern hemisphere. We looked through the 3C Catalogue and chose three radio galaxies with classical double-lobed structures, measured redshifts, and position well outside the galactic plane to avoid contamination by objects in the Milky Way. Our initial choices were 3C285, 3C265, and 3C390.3.

We took limiting IIIa-J plates, using a GG 385 filter, of these sources at the Kitt Peak 4 metre telescope, in March 1977. The seeing was better than one arcsecond and the plates showed images of ~ 24th magnitude. Tyson took several plates of each radio source, and analyzed them on the Berkeley PDS and the Kitt Peak Interactive Picture Processing System (IPPS) machines. In all three cases we found optical emission within one or two arcseconds of the radio peak in the most powerful component of each source. Their visual magnitudes are typically between 22nd and 23rd. Preliminary results of this work have been pub-

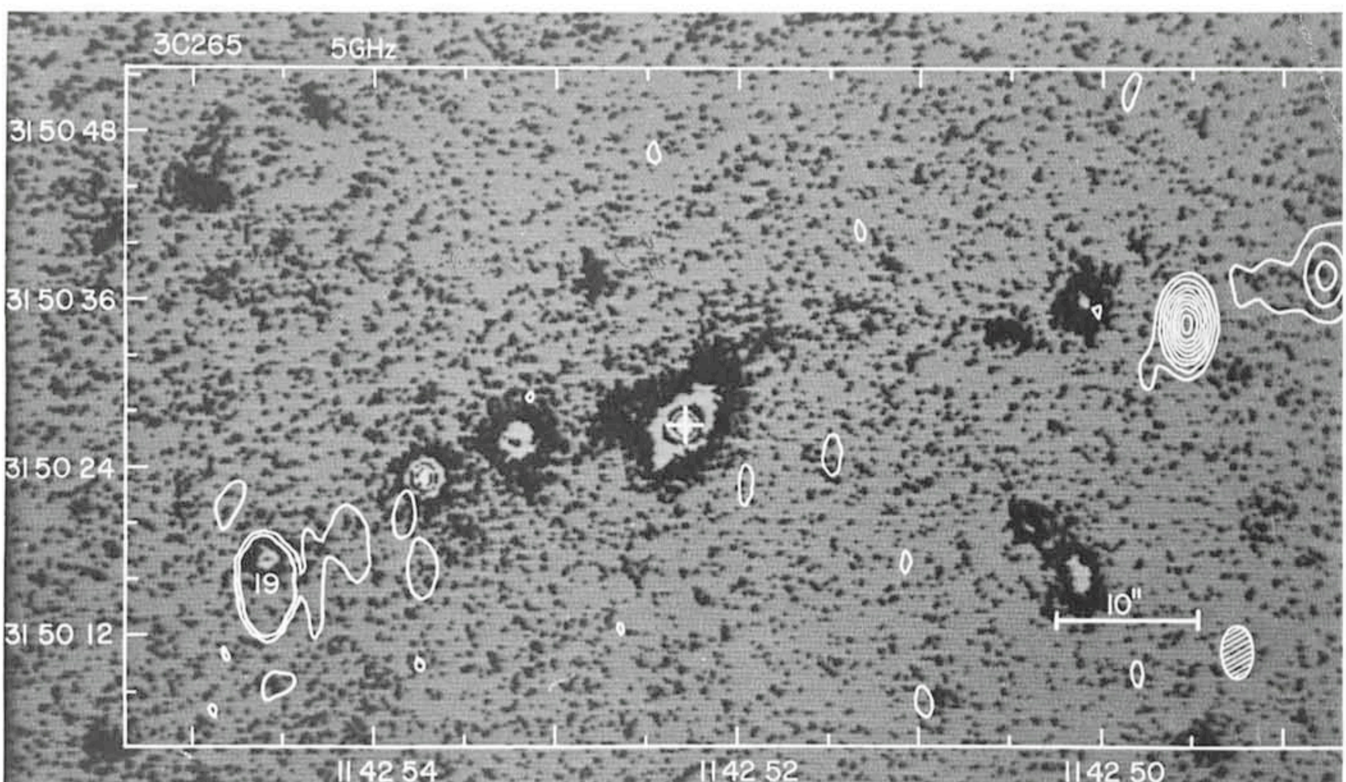

Fig. 2. — *This shows a sum of three 4-metre plates of the distant radio galaxy 3C265. The 5 GHz radio map is overlaid. There is an optical object coincident with the radio peak in the lower left. Many radio contours have been left out here in the extremely bright radio spot.*

lished (Tyson, Crane and Saslaw; *Astron. & Astrophys.*, **59** LIS, 1977) and a more definitive paper will be published in the *Astrophysical Journal* (see also ESO preprint No. 9).

The objects we have the most information about lie in the east radio lobe of 3C285, shown in Figure 1. The 15.5-magnitude galaxy in the centre has a redshift Z = 0.0797, putting it 320 Mpc away if the Hubble constant is 75 km s^{-1} Mpc. The galaxy is distorted, possibly by tidal interaction with nearby companions, and may even be of spiral type. It radiates about 3 x 10^{41} erg s^{-1} in the radio lobes, and the radio maps were made at 2.7 GHz with the Cambridge 5 km synthesis telescope.

In the centre of the radio lobe lies a 20.6-visual-magnitude optical object, which may be diffuse. Its optical emission is quite peculiar. The colours are very blue; using the 2.1 metre Kitt Peak telescope, we found photometric values B–V = 0.26 ± 0.4, U – B = –1.2 ± 0.5 magnitude. These colours are much more blue than normal Seyfert galaxies. They are the colours of quasars. Moreover, we also find that its radiation is 10 ± 5 % linearly polarized. This suggests it is optical synchrotron. Its power would be consistent with an extrapolation of the radio synchrotron emission into the optical regime. To produce optical synchrotron requires something on the radio lobe to generate highly relativistic electrons with $\gamma = (1-(v/c)^2)^{-0.5} \gtrsim 3 \times 10^6$.

There is another optical object in this radio lobe. It is of blue magnitude 23.6 and coincides with the region of peak radio emission to within one arcsecond. It is too faint to measure accurate colours or polarization with the KPNO 2.1 metre telescope, but we hope to find this information with the KPNO 4 metre. The probability of an optical object of 24th magnitude or brighter lying within one arcsecond of anywhere on our plate is about 3 x 10^{-3}.

The second radio galaxy we looked at, 3C265, is associated with a 20th-magnitude galaxy having redshift Z = 0.811. Figure 2 shows our plate with the Cambridge 2.7 GHz map superimposed. There is a remarkable choice of seven optical objects having about the same angular extent and position angle as the radio double. Again the strongest radio lobe coincides with an optical object, this time with B = 22.4 magnitude. We plan to measure its other optical properties in the near future.

The third radio galaxy, 3C390.3, is identified with a V = 15.4-mag N-type galaxy. One of the radio lobes, shown in Figure 3, is near a peculiar optical structure which points away from the central galaxy. An optical extension of this structure is seen to coincide with part of this radio lobe, which is itself double. A preliminary observation suggests the optical emission from this peculiar structure may also be polarized, but we want to repeat this measurement more sensitively.

The random probability of finding all these associations between optical objects and radio lobes is very small. But we plan to look at more radio galaxies to determine whether we have discovered the "tip of an iceberg" of information. If so, a new astronomical industry will soon arise, based upon radio, optical, and perhaps infrared, ultraviolet and x-ray emission from sources ejected by galaxies.

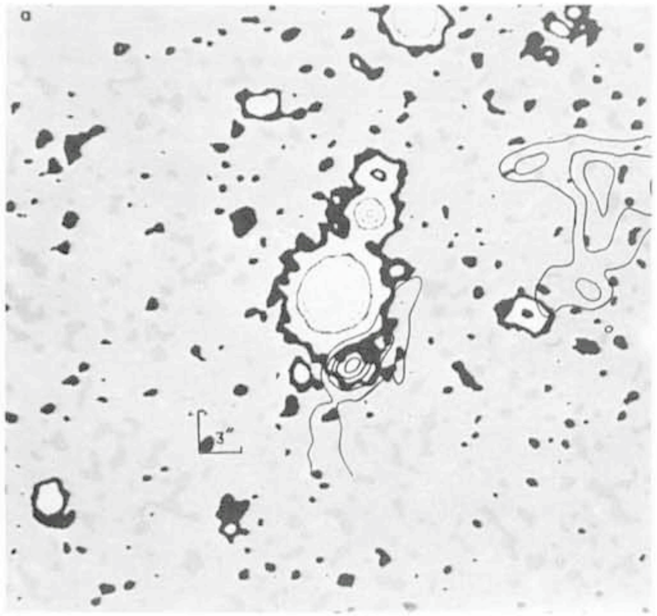

Fig. 3. — *This shows the north-west radio lobe of the radio galaxy 3C390.3. The galaxy itself is several minutes of arc away to the lower left. Several radio contours have been overlaid here to show a probable faint source just coincident with the radio peak. The bright object just above has V = 19.6 and the same redshift as the parent galaxy of 3C390.3. This picture is 45" across.*

Peculiar A-type Stars at ESO

H.-M. Maitzen and W. W. Weiss

The study of peculiar A stars is a fascinating chapter of modern astronomy. It combines measurements of light variability, variable spectral lines and magnetic fields. This review article by two Austrian astronomers, Drs. H.-Michael Maitzen and Werner W. Weiss from the Figl-Observatorium für Astrophysik (Vienna) discusses not only the observations, but also the attempts to explain theoretically the Ap phenomenon. It is probably true to say that the stellar models still are somewhat uncertain, but new and improved observational methods continuously refine the interpretation. The authors are frequent observers on La Silla.

Thirty years ago H. Babcock found for the first time a stellar magnetic field (78 Vir). Not quite as old is the history of Ap-star research at ESO. However, there exists already a long list of observational programmes in this field which were carried out at La Silla since ESO was founded. In what follows, we will try to give a very short historical background and our related contribution based on observations obtained at ESO.

Magnetic Fields

Babcock's observations for his famous catalogue of magnetic stars (1958) were made with a simple Zeeman analyzer in front of the slit of a coudé spectrograph which was designed by himself. This analyzer permits to separate left- and right-hand circular polarized components of stellar lines which are split by a magnetic field. Using the Landé g-factor and the measured shift between both components of a particular line, one can determine the longitudinal component of a stellar magnetic field averaged over the